8.—On Beryl from Western Australia

By P. L. C. Grubb*

Manuscript received—19th November, 1963

Varieties of pink, light blue, and white beryl are described from two localities in Western Australia. Their contrasting features are examined by optical, physical, x-ray diffraction, chemical, and spectrographic means. The slight differences in colour are considered to be caused by a variety of factors including trace element distribution, minute partially crystallised fluid inclusions, and the degree of incipient kaolinisation. The effect of alkali ion content on unit cell parameters is examined but fails to reveal any consistent relationship. Finally, the nature and composition of former liquid inclusions is briefly analysed and comparisons with other reported samples drawn.

Introduction

Of the three varieties of beryl discussed here, two (the light blue and white) were collected from the undulating Mt. Marion pegmatite sheet (Lat. 31° 5′ S., Long. 121° 30′ E.), where they form part of a single large zoned crystal. The third (a reportedly caesium-bearing type) was obtained from a pegmatite body at Wodgina (Lat. 21° 25′ S., Long. 118° 30′ E.).

Optical and X-Ray Diffraction Properties

Zoning.—Although isomorphous replacements of several elements within the beryl crystal lattice are common, macro- and microscopic zoning of single crystals appears to be quite rare. The total diameter of the zoned Mt. Marion crystal is of the order of 3 cm and the outer cloudy white zone is between 4 and 8 mm thick. The junction of these two zoned portions is quite sharp, but in one section it consists of a gradational fine-scale repetition of these.

Refractive indices.—Slight variations in refractive indices between the three main beryls exist (Table 1), and it is noteworthy that in the pink Wodgina beryl the incipiently kaolinised portions have refractive indices up to 0.002 higher than the fresh grains.

TABLE 1

Refractive indices of Western Australian beryls

	1	2	3	4
Ne ...	1·577	1·576	1·581	1·576
No ...	1·586	1·588	1·591	1·583

1. Light blue core } Mt. Marion zoned beryl crystal
2. Cloudy white margin }
3. Pink beryl from Wodgina
4. Clear green beryl from Yinnietharra (Norrish 1950)

Inclusions.—In all three beryls microscopic rod-like inclusions occur, these being most conspicuous in the clear light blue and pink varieties (Fig. 1 and 2). Despite their superficial resemblance to those figured by Little (1960) however, these differ in being partially or sometimes wholly crystalline so that on fine pulverising—particularly in the Wodgina beryl—they can be isolated from larger grains and their refractive indices compared with those of immersion oils.

Fig. 1.—Rod-like quartz inclusions in Mt. Marion beryl. Plain polarised green light. X 250 magnifications.

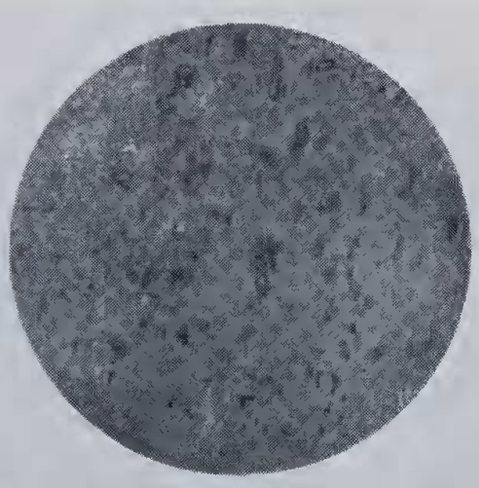

Fig. 2.—Fluorite inclusions in pink beryl from Wodgina, Western Australia. Plain polarised green light. X 480 magnifications.

Identification of these solid inclusions was carried out by x-ray diffraction with the result that traces of quartz were discerned in the light blue variety and of fluorite in that of Wodgina.

* C.S.I.R.O., Mineragraphic Investigations, c/o University of Melbourne, Parkville, N.2, Vic. Australia.

It is also of interest to note that whereas Norrish (1950) observed minute tubular inclusions of "water" parallel to the "c" crystallographic axis in beryl from Yinnietharra, he found no evidence of this water in a complete chemical analysis of the same specimen.

Alteration.—Although no traces of secondary alteration products were detectable by x-ray diffraction means, close scrutiny under high magnification revealed a slight dusting effect of some grains in the cloudy white variety and to a lesser extent in the pink variety. This, as at Mt. Marion, is coupled with a slightly higher loss-on-ignition of the outer white crystal margin compared with the clear light blue core. It seems logical to conclude therefore, that the conspicuous white appearance of some beryl from Mt. Marion is caused by incipient kaolinisation.

Unit cell parameters.—Calculation of the unit cell parameters for the three beryl types from Mt. Marion and Wodgina show slight divergencies but this appears to bear no evident relationship to their chemical composition (Table 2). No support therefore can be found here for the hypothesis of Sosedko (1957) and Frank-Kamenetsky & Sosedko (1958) that the "c" unit cell parameter increases stoichiometrically with the alkali content due to the crystal lattice distortion caused by the substitution of small beryllium ions by larger alkali ions. Neither does there appear to be a very constant relationship between the "a" unit cell parameter and total alkali ion content as suggested by Schaller, Stevens and Jahns (1962).

Specific gravities.—Specific gravities determined using the Berman precision balance show the highest values for the pink Wodgina beryl, whereas the cloudy white Mt. Marion beryl, being slightly kaolinised, is less than its light blue counterpart (Table 2).

Chemical analyses.—Partial chemical analyses of the three beryl types from Wodgina and Mt. Marion are listed in Table 2. In addition qualitative and semi-quantitative spectrographic anaylses of each showed slightly higher contents of cobalt and manganese in the pink Wodgina sample, slightly more titanium and zinc in the blue Mt. Marion type, and rather more aluminium, magnesium, calcium, iron, chromium, sodium, and lithium in the white Mt. Marion beryl. It is of interest, however, that no caesium could be detected in any of the samples studied.

Conclusions

Inclusions in beryl, although rare, have recently been described from several world localities, yet for the most part these are believed to be fluid bodies consisting essentially of water, carbon dioxide, and sulphur (Little 1960 and Zwaan 1958). Eppler (1958), on the other hand, considers that the chatoyancy exhibited in some beryl crystals is due to minute oriented ilmenite needles. Subsequently (1960) in an almost opaque beryl sample showing asterism, he recorded thin tabular pyrrhotite crystals, crystal groups of quartz and epidote, rod-like apatite, and clusters of pyrite. Most recently Schaller, Stevens, and Jahns (1962) have recorded oriented inclusions of quartz, tourmaline and fluorite in an unusual beryl from Arizona.

The inclusions in both the Mt. Marion and Wodgina beryls, although now largely crystalline, appear to have consisted of the late residual fluid existing while the beryl was in the

TABLE 2

Chemical composition and calculated unit cell constants for beryl

	1	2	3	4	5	6	7
SiO_2	....	....	....	64·85	65·32	64·17	61·88
BeO	....	....	..	13·15	12·60	11·82	10·54
Al_2O_3	....	....	....	17·52	17·77	17·42	17·10
Fe_2O_3	....	..	..	0·37	0·13	0·12	0·08
MgO	....	....	....	0·14	0·25	0·21	0·22
CaO	trace	trace	0·07	nil	0·26	0·44	0·44
Li_2O	0·34	0·60	0·64	0·52	0·30	1·23	0·60
MnO	....	.	....	0·01	trace	nil	trace
Na_2O	0·64	1·66	1·00	0·94	1·27	1·39	2·50
K_2O	0·16	0·16	0·16	0·16	nil	nil	nil
(Rb Cs)$_2$O	nil	nil	nil	0·08	0·27	0·67	4·13
$H_2O+105°C$	2·10	2·55	1·84	2·19	1·76	1·88	2·26
$H_2O-105°C$	0·70	0·00	0·00	nil	0·08	0·60	0·16
TiO_2	trace	trace	....	nil	0·01	0·01	0·01
P_2O_5	....	.	..	nil	....	....	....
Cr_2O_3	trace	trace	....	nil	....	....	....
F	....	....	..	nil	....	...	....
Cl	...	....	....	nil	..	....	..
				99·93	100·02	99·96	99·92
Unit Cell Constants							
a	9·15	9·19	9·20	9·188	9·202	9·202	9·200
c	9·21	9·17	9·21	9·189	9·183	9·209	9·227
c/a	1·006	0·998	1·001	1·000	0·998	1·0008	1·003
Specific Gravity	2·71	2·70	2·84	2·71	2·72	2·75	2·78

1. Clear light blue core zone of Mt. Marion beryl, Western Australia.
2. Cloudy white margin of Mt. Marion beryl, Western Australia.
3. Light pink beryl from Wodgina, Western Australia.
4. Clear light green beryl from Yinnietharra, Western Australia. (Norrish 1950.)
5. Green beryl from pegmatite, U.S.S.R.
   White beryl from pegmatite, U.S.S.R. } Sosedko, T.A. (1957).
   nk beryl from pegmatite, U.S.S.R.

process of crystallising. So that while at Wodgina the residuum was essentially fluorine-rich, at Mt. Marion it was correspondingly siliceous.

Although the cloudy white nature of some Mt. Marion beryl is readily explained through late stage kaolinisation, the pink and blue colours of the remaining two varieties is not so readily understood. Nevertheless, it is considered that these characteristics may arise through the contrasting distribution of trace elements; the pinkish hue being due to the presence of cobalt and manganese, and the blue probably to chromium. An additional factor, particularly in the pink Wodgina beryl may be the anomalous refraction effects produced by its minute fluorite inclusions.

Acknowledgments

For critical reading and comments of this note the writer is indebted to Mr. A. J. Gaskin, Chief of Division of Applied Mineralogy, C.S.I.R.O.

The partial chemical analyses of the new varieties of beryl were carried out by Mr. T. H. Donnelly, to whom much thanks is due.

References

Eppler, W. F. (1958).—Notes on asterism in spinel and chatoyancy in chrysoberyl, quartz, tourmaline, zircon, and scapolite. *J. Gemm.* 6: 251-263.

————(1960).—An unusual star-beryl. *J. Gemm.* 7: 183-191.

Frank-Kamenetsky, V. A., & Sosedko, T. A. (1958).—On the character of isomorphism in alkaline beryls. *C. R. Acad. Sci. U.R.S.S.* 118: 815-817.

Little, W. M. (1960).—Inclusions in cassiterite and associated minerals. *Econ. Geol.* 55 (3): 485-509.

Norrish, K. (1950).—An x-ray study of West Australian beryl. *J. Roy. Soc. W. Aust.* 34: 1-16.

Schaller, W. T., Stevens, R. E., and Jahns, R. H. (1962).—An unusual beryl from Arizona. *Amer. Min.* 47: 672-699.

Simpson, E. S. (1948).—"Minerals in Western Australia." Vol. 1 (Government Printer: Perth.)

Sosedko, T. A. (1957).—The change of structure and properties of beryls with increasing amounts of alkalies. *Zap. Vsesoyuz. Miner. Obshch.* 86: 495-499.

Zwaan, P. C. (1958).—Remarks on the inclusions in an aquamarine. *Proc. Acad. Sci. Amst. (B)* 61: 260-264.